G 1/PRTS

[001] MULTI-STEP GEARBOX

[002]

[003]

[004] The present invention concerns a multi-step reduction gear in planetary construction, especially an automatic transmission for a motor vehicle in accordance with the preamble of claim 1.

[005]

[006] Automatic transmissions, especially for motor vehicles, include planetary gears according to the state of the art, which are shifted using friction or shifting elements such as clutches and brakes, and are usually connected with a starting element subject to a slipping action, and are optionally provided with a bridging clutch such as, perhaps, a hydrodynamic torque converter or a fluid clutch.

[007] A transmission of this type emerges from EP 0 434 525 A1. It basically includes a drive shaft and an output shaft, which are arranged parallel to each other, and double planetary gears arranged concentrically in relation to the output shaft, and five shifting elements in the form of three clutches and two brakes, whose selective blockage respectively determines in pairs the different gear reductions between the drive shaft and the output shaft. Hereby, the transmission has a control gears and two power paths, so that six forward gears can be attained through the selective engagement in pairs of the five shifting elements.

[008] Hereby, two clutches are needed in connection with the first power path to transmit the torque from the control gears to two elements of the double planetary gears. These are basically arranged behind the control gears in the direction of the double planetary gears in the direction of the flow of force. A further clutch is provided in connection with the second power path, which detachably connects this with a further element of the double planetary gears. Hereby, the clutches are arranged in such a way, that the internal disk support forms the output.

[009] Furthermore, a compact multi-step reduction gear in planetary construction, especially for a motor vehicle, is known from the publication US 6,139,463, which has two planetary gears, and control gears, as well as three clutches and two

brakes. Two clutches C-1 and C-3 are provided with this known multi-step reduction gear in connection with a first power path for transmitting the torque from the control gears to the two planetary gears. Hereby the external disk support, or the cylinder, or the piston, or the pressure compensation side of clutch C-3 is connected with a first brake B-1. Moreover the internal disk support of the third clutch C-3 is connected with the cylinder, or piston, or pressure compensation side of the first clutch C-1, whereby the internal disk support of the first clutch C-1 is arranged on the output side, and is connected with a sun wheel of the third planetary gears.

[010] Moreover, a multi-step reduction gear is known from DE 199 49 507 A1 of the applicant, in which two non-shiftable control gears are provided on the drive shaft, which generate two RPMs on the output side that can, in addition to the RPM of the drive shaft, be shifted electively to shiftable double planetary gears acting on the output shaft through selective closing of the shifting elements used in such a way, that in each case only one shifting element of the two shifting elements just activated must be engaged or disengaged for shifting from one gear into the respectively next following higher or lower gear.

[011] Furthermore, an automatically shiftable motor vehicle transmission with three single rod planetary gears, as well as three brakes and two clutches for shifting six forward gears, and one reverse gear, and with a drive shaft, as well as an output shaft is known from DE 199 12 480 A1. The automatically shiftable motor vehicle transmission is constructed in such a way, that the drive shaft is directly connected with the sun wheel of the second planetary gears, and that the drive shaft can be connected with the sun wheel of the first planetary gears through the first clutch, and/or through the second clutch with the rod of the first planetary gears. In addition or as an alternative, the sun wheel of the first planetary gears can be connected through the first brake with the housing of the transmission, and/or the rod of the first planetary gears through the second brake with the housing, and/or the sun wheel of the third planetary gears through the third brake with the housing.

[012] The present invention is based upon the objective of proposing a multi-step reduction gear of the type named at the beginning, in which the construction expenditure is optimized, and moreover the degree of efficiency in the main driving gears is improved with respect to drag and gearing losses. Moreover, low torques should be acting on the shifting elements and planetary gears in the multi-step reduction gear of the invention, and the RPMs of the shafts, shifting elements and planetary gears should be kept as low as possible. Furthermore, the number of gears as well as the transmission ratio spread should be increased.

[013] This objective is accomplished in accordance with the invention through the features of patent claim 1. Further advantages and refinements will emerge from the dependent claims.

[014]

[015] Accordingly, a multi-step reduction gear in planetary construction of the invention is proposed, which has a drive shaft and an output shaft, that are arranged in a housing. Furthermore, at least three single rod planetary gears, at least seven rotational shafts, and at least six shifting elements, including brakes and clutches are provided, whose selective engagement effects various reductions between the drive shaft and the output shaft, so that preferably seven forward gears and one reverse gear can be realized.

[016] In accordance with the present invention, it is provided in connection with the multi-step reduction gear, that the drive takes place through a shaft, which is continuously connected with the sun wheel of the first planetary gears, and such that the output takes place through a shaft, which is connected with the annulus of the second planetary gears, and an element of the third planetary gears. Furthermore, with the multi-step reduction gear of the invention, it is provided, that a third shaft is continuously connected with the rod of the first planetary gears, that a fourth shaft is continuously connected with the rod of the second planetary gears, and a further element of the third planetary gears, that a fifth shaft is continuously connected with a further element of the first planetary gears, that a sixth shaft is continuously connected with the sun wheel of the second planetary

gears, and that a further, seventh shaft is continuously connected with the sun wheel of the third planetary gears, whereby the planetary gears are coupled with shafts and shifting elements. Hereby, the drive shaft of the invention can be connected either with the rod, or with the sun wheel of the first planetary gears, whereby the fifth shaft is connected with the sun wheel, or the rod of the first planetary gears.

[017] In the framework of a preferred embodiment, the output shaft is connected with the annulus of the second planetary gears, and the annulus of the third planetary gears, whereby in this case the fourth shaft is connected with the rod of the second and the rod of the third planetary gears, and the first planetary gears and the third planetary gears are constructed as positive planetary gears, and the second planetary gears as negative planetary gears.

[018] In accordance with a further embodiment, the output shaft is connected with the annulus of the second planetary gears and the rod of the third planetary gears, whereby in this case the fourth shaft is connected with the annulus of the third planetary gears and the rod of the secondary planetary gears, and the second and third planetary gears are constructed as negative planetary gears, and the first planetary gears as positive planetary gears.

[019] Several suitable reductions, as well as a considerable increase of the overall ratio spread of the multi-step reduction gear are the result of the configuration of the multi-step reduction gear in accordance with the invention, owing to which, an improvement in driving comfort and a significant reduction in consumption are brought about.

[020] The multi-step reduction gear of the invention is suitable for any motor vehicle, especially for passenger cars and for commercial motor vehicles, such as, for example, trucks, busses, construction vehicles, rail vehicles, caterpillar vehicles and the like.

[021] In addition, the construction expenditure is reduced with the multi-step reduction gear of the invention through a low number of shifting elements, preferably four clutches and two brakes. With the multi-step reduction gear of the invention, it is advantageously possible to conduct a start with a hydrodynamic

converter, an external starting clutch or also with other suitable external starting elements. It is also conceivable, to enable a starting procedure with a starting element incorporated into the transmission. Preferably a shifting element, which is activated in first gear and in reverse gears is suitable.

[022] In addition, a good degree of efficiency in the main driving gears is achieved with the multi-step reduction gear of the invention with respect to drag and gearing losses.

[023] Moreover, low torques are present in the shifting elements and the planetary gears of the multi-step reduction gear, owing to which the wear and tear on the multi-step reduction gear is advantageously reduced. Furthermore, a correspondingly small dimensioning is made possible due to the low torques, owing to which, the space required and the corresponding costs can be reduced. In addition, low RPMs are also present in the shafts, shifting elements and planetary gears.

[024] Furthermore the transmission of the invention is designed in such a way, that an adaptability to different power train configurations in the direction of the flow of force, as well as with respect to space is made possible.

[025]

[026] The invention will be explained in greater detail below by way of example on the basis of the drawings, wherein:

[027] Fig. 1 represents a schematic view of a preferred embodiment of a multi-step reduction gear of the invention;

[028] Fig. 2 represents a schematic view of an additional preferred embodiment of a multi-step reduction gear of the invention;

[029] Fig. 3 represents a shifting diagram for the multi-step reduction gear of the invention in accordance with Fig. 1 and Fig. 2; and

[030] Fig. 4 represents a schematic view of a further, preferred embodiment of a multi-step reduction gear of the invention.

[031]

[032] Fig. 1 shows a multi-step reduction gear of the invention with a drive shaft 1 (An) and an output shaft 2 (Ab), which are arranged in a housing G. Three single rod planetary gears P1, P2, P3 are provided. Hereby, the first planetary gears P1 and the third planetary gears P3 are constructed as positive planetary gears. The second planetary gears P2 is constructed as negative planetary gears in accordance with the invention. It is also possible, that the second planetary gears P2 and the third planetary gears P3 are combined as Ravigneaux planetary gears with common rod and common annulus.

[033] As is apparent from Fig. 1 and 2, only six switching elements, namely two brakes 03, 04, and four clutches 14, 17, 36 and 56 are provided.

[034] A selective shifting of seven forward gears and a reverse gear can be realized with the shifting elements. The multi-step reduction gear of the invention has a total of seven rotational shafts in accordance with Fig. 1, namely the shafts 1, 2, 3, 4, 5, 6, and 7.

[035] In accordance with the invention, it is provided with the multi-step reduction gear of the invention, according to Fig. 1, that the drive takes place through shaft 1, which is continuously connected with the sun wheel of the first planetary gears P1. The output takes place through shaft 2, which is connected with the annulus of the second planetary gears P2 and the annulus of the third planetary gears P3. Furthermore, shaft 3 is continuously connected with the rod of the first planetary gears; shaft 4 is continuously connected with the rod of the second planetary gears P2 and the rod of the third planetary gears P3. In addition, shaft 5 is continuously connected with the rod of the first planetary gears P1. The additional rotational shaft 6 is continuously connected with the sun wheel of the second planetary gears P2; shaft 7 with the sun wheel of the third planetary gears P3 in accordance with the invention.

[036] With the multi-step reduction gear of the invention, shaft 3 can be coupled onto the housing G through the brake 03 and the shaft 4 through the brake 04. The clutch 14 connects shaft 1 and shaft 3 detachably with one another. Shaft 1 and shaft 7 are detachably connected with each other through clutch 17.

Furthermore, clutch 36 detachably connects shafts 3 and 6, and clutch 56 detachably connects shafts 5 and 6 with each other.

[037] A further embodiment of the multi-step reduction gear of the invention is shown in Fig. 2. Hereby, the second planetary gears P2 and the third planetary gears P3 are constructed as negative planetary gears. The first planetary gears P1 are constructed as positive planetary gears in accordance with the invention. A further difference to the embodiment of Fig. 1 consists in that the output shaft 2 is connected with the annulus of the second planetary gears P2 and the rod of the third planetary gears P3, and in that shaft 4 is continuously connected with the rod of the second planetary gears P2 and the annulus of the third planetary gears P3.

[038] A shifting diagram of the multi-step reduction gear of the invention in accordance with Fig. 1 and 2 is represented in Fig. 3. The respective reductions i of the individual gear stages and the stage progressions φ to be determined on their basis can be inferred by way of example. Furthermore, it can be inferred from the shifting diagram, that double shifts can be avoided with sequential modes of shifting, since two adjacent gear steps respectively use two shifting elements in common.

[039] The brake 03 is continuously closed for the seven forwards gears. In addition, brake 04 and clutch 56 are activated for the first gear, for second gear, brake 04 and clutch 17, for the third gear, clutch 17 and clutch 56, for the fourth gear, clutches 17 and 36, for the fifth gear, clutches 14 and 17, for the sixth gear, clutches 14 and 36, and for the seventh gear, clutches 14 and 56. In reverse gear R, brake 04 and clutches 36 and 56 are activated as shift elements.

[040] Within the framework of a further variant of the embodiments shown in Figs. 1 and 2, the fixed connections of the first planetary gears P1 can be exchanged, so that the shaft 1 is continuously connected with the rod of the first planetary gears P1, and that the shaft 5 is continuously connected with the sun wheel of the first planetary gears P1.

[041] This is shown in Fig. 4 by way of example, in which a transmission is illustrated, which differs from the transmission according to Fig. 2 in that shaft 1 is

continuously connected with the rod of the first planetary gears P1, and shaft 5 is continuously connected with the sun wheel of the first planetary gears P1.

[042] It is possible in accordance with the invention to provide additional free wheelings at each suitable position of the multi-step reduction gear, for example to be connected between a shaft and the housing or about two shafts if need be.

[043] Moreover it is possible through the mode of construction of the invention, to arrange the drive and output on the same side of the transmission or the housing preferably for transverse, frontal, longitudinal, back longitudinal or all-wheel arrangements. Moreover, an axle differential and/or a distributor differential can be arranged on the drive side or on the output side.

[044] The drive shaft 1 can be separated by a clutch element from a drive motor as needed within the framework of an advantageous further development, whereby a hydrodynamic converter, a hydraulic clutch, a dry starting clutch, a wet starting clutch, a magnetic powder clutch, or a centrifugal force can be used as clutch element. It is also possible to arrange a starting element of this type behind the transmission in the flow of force direction, whereby in this case the drive shaft 1 is continuously connected with the crankshaft of the motor. The start up according to the invention can take place using a shifting element of the transmission. Preferably the brake 04, which is activated in the first forward gear, as well as in the first reverse gear, can be used.

[045] The multi-step reduction gear of the invention moreover enables the arrangement of a torsion vibration damper between motor and transmission.

[046] A wear-free brake, such as, for example, a hydraulic or electric retarder or the like, can be arranged on any shaft, preferably on the drive shaft 1 or the output shaft 2, which is especially of significance for use in commercial motor vehicles within the framework of a further, not represented embodiment. Furthermore, an auxiliary output can be provided preferably on the drive shaft 1 or the output shaft 2 for driving additional units on each shaft.

[047] The shifting elements used can be constructed as load-shifting clutches or brakes. In particular, force-locking clutches or brakes such as, for example, disk clutches, strap brakes and/or cone clutches can be used. Furthermore, form-

locking brakes and/or clutches, such as, for example, synchronizations or claw clutches, can be used as shifting elements.

[048] A further advantage of the multi-step reduction gear presented here consists in that an electric machine can be installed on each shaft as generator and/or as additional drive machine.

[049] The functional features of the claims can be constructionally built in the most different types of ways. These constructional development possibilities are not being explicitly described for the sake of simplicity. Obviously each constructional development of the invention nonetheless falls under the scope of protection of the claims, especially any spatial arrangement of the planetary gears or the shifting elements in themselves or toward one another and to the extent to which they are technically appropriate.

Reference number	
1	shaft
2	shaft
3	shaft
4	shaft
5	shaft
6	shaft
7	shaft
03	brake
04	brake
14	clutch
17	clutch
36	clutch
56	clutch
P1	planetary gears
P2	planetary gears
P3	planetary gears
An	drive
Ab	output
i	reduction
φ	step progression
G	housing